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Latest HexSim NSO scenario

1 message

Nathan Schumaker <[redacted]> **Mon, Jun 28, 2010 at 11:51 AM**
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Cc: "[redacted]" <[redacted]>

Hello all,

I've updated my HexSim spotted owl baseline scenario, based on the feedback I got from Bob Anthony. I've also updated and improved on the scenario description.

Bob was concerned that (1) there was a lot of variability in home range size in the parts of the owl's range that I'd collapsed into a single zone, and (2) that my cut-off values for transitioning between the low and medium, and the medium and high resource classes might be too low.

To address Bob's first concern, I've altered the simulation so that it implements separate home range sizes and resource targets for each province.

To address Bob's second concern, I've changed the target resource values and cut-offs to reflect his suggestions. See the attached scenario description for the details. *These cut-off values are the principal tuning parameters that will increase population size up or down.*

I'd like to get some feedback on this iterate of the baseline HexSim scenario.

To help you size it up, I'm also attaching a PDF file showing population size in time, and an occupancy map. The occupancy map reflects years 150-250. Low to mid to high occupancy areas are shown in colors ranging from red to yellow to green.

I'm also attaching DSA counts (owls per DSA) for years 50-150 and for years 150-250. These are text files.

Remember, this simulation is for female owls only. So population sizes are just females.

I modified the simulation so that it tracks the mean score of home range hexagons, and the mean score of territory hexagons. So finally, I'm attaching these values, so you can see the distributions if you want. They are text files.

Here is what I'd like you to focus on, at minimum:

1. Is the life cycle reasonable? See the first page of the scenario description.
2. Is my cross-walk between modeling regions and provinces correct and adequate?

3. Are my province-specific data (territory size, territory resource targets, home range size, home range resource targets) acceptable. I suspect there is more variability in home range size than captured here...
4. Are my assumptions reasonable in the section titled "notes on range size and resources"?
5. Are my assumptions reasonable in the section titled "notes on movement"?
6. Are the population size data in the attached files too high or too low?
7. Is it reasonable to assume that breeding quality hexagons are those scored 60 and above (in the MaxEnt data)?
8. How will we add the barred owl influence on survival given that I've stratified survival rates by stage class and resource acquisition class?

Sorry to throw so much your way. I'll upload the latest owl workspace, including these files (look in the Analysis folder), to Brendan's FTP site.

Nathan

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7 attachments

Occupancy (150-250).png
666K

DSA Numbers (50-150).txt
1K

NSO Scenario Description.pdf
365K

Popsize.pdf
17K

DSA Numbers (150-250).txt
1K

Explored Area Quality (150-250).txt
1K

Range Quality (150-250).txt
1K

Notes on the HexSim Life Cycle

At present, the HexSim spotted owl life cycle has the following items (in this order). See the notes below for further discussion.

Event	Description
Increment Age	Every owl gets one year older.
Floater Prospecting	Each floater prospects over an area no larger than 43,300 hectares, in hopes of constructing a territory.
Set Nesting Fractions	Consists of two HexSim events. In odd years, 30% of territorial owls are set to nest. In even years, this value increases to 70%.
Reproduction	Reproduction is stratified by stage class, and only nesting territorial owls are allowed to reproduce. See notes on the reproduction below.
Floater Creation	Every new recruit is assigned floater status.
Dispersal	Recruits disperse a maximum of 250 km. Dispersers stop if they encounter a hexagon scored 60 and above. Repulsion increases from 0 in hexagons scored 10 to 90% in hexagons scored 0.
Record Locations	Individual owls determine which modeling region and DSA (if any) they are located in.
Set Home Ranges	Home ranges are constructed separately for each province. See the notes on range size and resources below.
Set Resource Targets	Resource targets are set separately for each province. See the notes on range size and resources, below.
Resource Acquisition	Resources are acquired from the owls home ranges. Resources are divided up when home ranges overlap. Owls compute the percent of their resource targets they have acquired, and use this value to set their resource class (low, moderate, high).
Record Use of Space	Mean hexagon quality is recorded for both home ranges and territories, and is used to set two accumulated traits. This is for data gathering only, it does not affect the simulation behavior.
Survival	Survival is stratified by stage class and resource class. See notes on the survival event, below.
Census	Multiple census events gather simulation output.

Notes on Range Size and Resources

Brendan developed the table of home range data below. I converted his values to hexagons, assuming a 86.6 hectare hexagon size (1 km width).

State	Province	Minimum Home Range Size		Median Home Range Size		Maximum Home Range Size	
		Hectares	Hexagons	Hectares	Hexagons	Hectares	Hexagons
WA	Olympic	1785	21	5775	67	11,052	128
WA	Cascades	780	9	2553	29	7258	84
OR	Cascades	584	7	1196	14	3949	46
OR	Coast Range	655	8	1929	22	4123	48
OR	Klamath	419	5	1352	16	3033	35
CA	Klamath	509	6	1352	16	3165	37

I've made the following *assumptions* about deriving HexSim parameter values from this data:

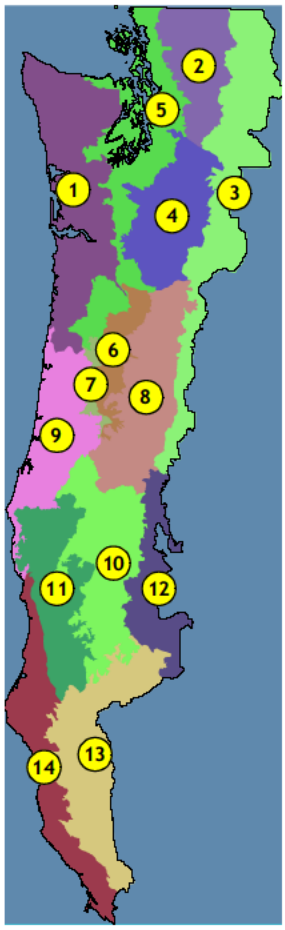
- Territory size can be approximated as the *minimum* home range size, and this approximation can be applied range-wide. I am assuming that home range size will decrease as resource quality increases, and will equal the territory size at the limit where a home range consists entirely of optimal quality resource. Secondly, I've assumed that territory size will not change with resource quality, and can be treated as a constant range-wide. The minimum home range size above is 5 hexagons, so I have set the HexSim maximum range (a territory) size to 5 hexagons. I am also assumed that hexagons with a score of 60 or more qualified as breeding habitat, and thus have set the resource target for territory construction to 5 x 60 = 300.

- The home range size in HexSim can be approximated by the *maximum* home range sizes in the table above. The assumption here is that spotted owls will expand their ranges as needed to acquire their requisite resources. Setting the home range size to the maximum observed value enables simulated owls to extract resources from an area this large, but they will not extract more resources than they need to satisfy their home range resource targets.

- The spotted owl resource targets for establishing resource rankings (subsequently used to stratify survival rates) can be set proportional to the *median* home range size. As with the resource targets for territory construction, I have obtained the resource targets by multiplying the values for median home range size by 60 -- the score at which hexagons are presumed to qualify as breeding habitat.

To spatially stratify resource targets and home ranges, HexSim needs a map that distinguishes areas with different distinct values. In order to create such a map, I've correlated the modeling regions (below right, supplied by Dave LaPlante) with the province-by-province data on home range size (above, supplied by Brendan White). These spatial correlations may be flawed, but this is the best I could come up with. See the table below.

ID	Modeling Region	Province
1	North Coast Olympics	WA Olympic
2	West Cascades North	WA Cascades
3	East Cascades North	
4	West Cascades Central	
5	Puget Willamette North	
6	Puget Willamette East	OR Cascades
7	Puget Willamette West	
8	West Cascades South	
9	Oregon Coast	OR Coast Range
10	Klamath East	OR Klamath
11	Klamath West	
12	East Cascades South	
13	Inner California Coast Ranges	CA Klamath
14	Redwood Coast	



I have parameterized HexSim so that simulated owls extract resources from their home ranges. But home ranges will frequently overlap, and when more than one range includes a given hexagon, that hexagon's resources are divided up equally among the owls using it. This creates a density-dependent feedback through the survival event. Territory size has no affect in the model other than setting an absolute upper limit on the density of territorial owls. The table below combines the data from the two tables and the three bulleted assumptions above. The table below is what I used to parameterize the simulated owls' use of space. The resource targets associated with the territory size values determine how large individual territories are. The resource targets associated with the home range values affect which resource acquisition class an owl will end up in. This is performed by comparing the resources that owls actually capture from their home ranges (given competition) to the resource target values. The territory and range values below are maximums. If resources are abundant, territory and home range sizes can decrease.

ID	Modeling Region	Province	Max Hexagons per Territory (Resource Target)	Max Hexagons per Home Range (Resource Target)
1	North Coast Olympics	WA Olympic	5 (300)	128 (4020)
2	West Cascades North	WA Cascades	5 (300)	84 (1740)
3	East Cascades North			
4	West Cascades Central			
5	Puget Willamette North			
6	Puget Willamette East	OR Cascades	5 (300)	46 (840)
7	Puget Willamette West			
8	West Cascades South			
9	Oregon Coast	OR Coast Range		48 (1320)
10	Klamath East	OR Klamath	5 (300)	35 (960)
11	Klamath West			
12	East Cascades South			
13	Inner California Coast Ranges	CA Klamath	5 (300)	37 (960)
14	Redwood Coast			

Notes on Survival Rates

I computed minimum, mean, and maximum survival values, for stage classes 1-3, from Table 12 of the Forsman et. al. manuscript (in press). To compute the minimum and maximum values, I first calculated the mean of each pair of male and female survival estimates for a specific stage class / study area combination. Then I found the lowest and highest estimates across all study areas.

Stage class 0 survival estimates were computed by Bob Anthony from Franklin et. al. 1999 (pp 27-28) titled Range-wide status and trends in northern spotted owl populations. The values Bob gave me were adjusted to compensate for emigration rates, based on radio telemetry studies conducted by Eric Forsman.

The Stage class zero mean value was set to the midpoint between the minimum and maximum value. For the other stage classes, the mean value was computed from the full set of survival estimates in Table 12 (Forsman et. al, in press).

These survival rates are given in the table below:

Stage Class	Survival Minimum	Survival Mean	Survival Maximum
0	0.366	0.499	0.632
1	0.544	0.718	0.795
2	0.676	0.811	0.866
3	0.819	0.849	0.865

In the HexSim scenario, low, moderate, and high resource classes were established. Owls in the low resource class are assigned the minimum survival values. Owls in the moderate resource class are assigned the mean survival values. Finally, owls in the high resource class are assigned the maximum survival values.

Each owl is placed in either the low, moderate, or high resource class based on its ability to acquire resources. This resource acquisition process is measured relative to the owl's resource target, which changes by geographic zone. Resource acquisition is also affected by landscape quality and competition. Finally, two break points separate the spectrum of resource acquisition values (0-100% of an owls target resource) into three categories (low, moderate, and high).

I am currently using 20% for the break point separating the low and moderate resource categories. I'm using 40% as the break point separating the moderate and high resource categories. These values are subject to change, and are my most important free parameters.

Notes on Reproductive Rates

To parameterize HexSim's reproduction event, I have used the fecundity values from Forsman et. al. (in press), Table 3. This table lists the following stage-specific mean fecundity estimates:

Fecundity (stage 0) = 0.000
Fecundity (stage 1) = 0.070
Fecundity (stage 2) = 0.202
Fecundity (stage 3) = 0.330

In addition, Bob Anthony stated that the probability of having a clutch of size 1 apparently equals the probability of having a clutch of size 2. The probability of a clutch of size greater than 2 can be assumed to be 0.

Assume a sex-ratio of 50:50.

Given a clutch of size 1, the possible outcomes are: M, F.

Given a clutch of size 2, the possible outcomes are: MM, MF, FM, FF.

Let A = Probability of having 1 female offspring.
Let B = Probability of having 2 female offspring.

P(1 egg) = P(2 eggs) = 0.500
P(1 female given 1 egg) = 0.500
P(1 female given 2 eggs) = 0.500
P(2 females given 1 egg) = 0.000
P(2 females given 2 eggs) = 0.250

A = P(1 egg) x P(1 female given 1 egg) + P(2 eggs) x P(1 female given 2 eggs) = 0.500.
B = P(1 egg) x P(2 females given 1 egg) + P(2 eggs) x P(2 females given 2 eggs) = 0.125.

Therefore, we can conclude that A = 4B

Every even year our owls have a 70% likelihood of nesting. Every odd year our owls have a 30% likelihood of nesting. So on average, our owls have a 50% likelihood of nesting.

HexSim's reproduction event is user-stratified by trait combinations, and then parameterized with values for the probability of having each possible clutch sizes. The model then displays the expected value for each trait combination. In a females-only simulation, this expected value is equal to the fecundity, assuming all territorial animals are breeding. Since only 50% (on average) of our territorial owls will reproduce, the probabilities for associated with each clutch size must be set such that the expected value equals twice the actual fecundity. Thus we compute the expected values by doubling the fecundity estimates:

Fecundity (stage 0) = 0.000: Expected Value (stage 0) = 0.000
Fecundity (stage 1) = 0.070: Expected Value (stage 1) = 0.140
Fecundity (stage 2) = 0.202: Expected Value (stage 2) = 0.404
Fecundity (stage 3) = 0.330: Expected Value (stage 3) = 0.660

The expected value (EV) is, by definition, A + 2B. Since we know from above that A = 4B, we conclude that EV = 6B. Plugging in the values for EV above, we solve for B, and then for A:

For stage 0: A = 0.000; B = 0.000
For stage 1: A = 0.093; B = 0.023
For stage 2: A = 0.269; B = 0.067
For stage 3: A = 0.440; B = 0.110

Rounding errors were compensated for by incrementing the Stage 1 and 2 values for A by 0.001, and making up this difference in the probability of a zero-sized clutch. This produced the final set of reproduction parameters for HexSim. The values in the table below are probabilities that individuals of a given stage class will have the indicated clutch sizes:

	Clutch Size = 0	Clutch Size = 1	Clutch Size = 2	Expected Value
Stage 0	1.000	0.000	0.000	0.000
Stage 1	0.883	0.094	0.023	0.140
Stage 2	0.663	0.270	0.067	0.404
Stage 3	0.450	0.440	0.110	0.660

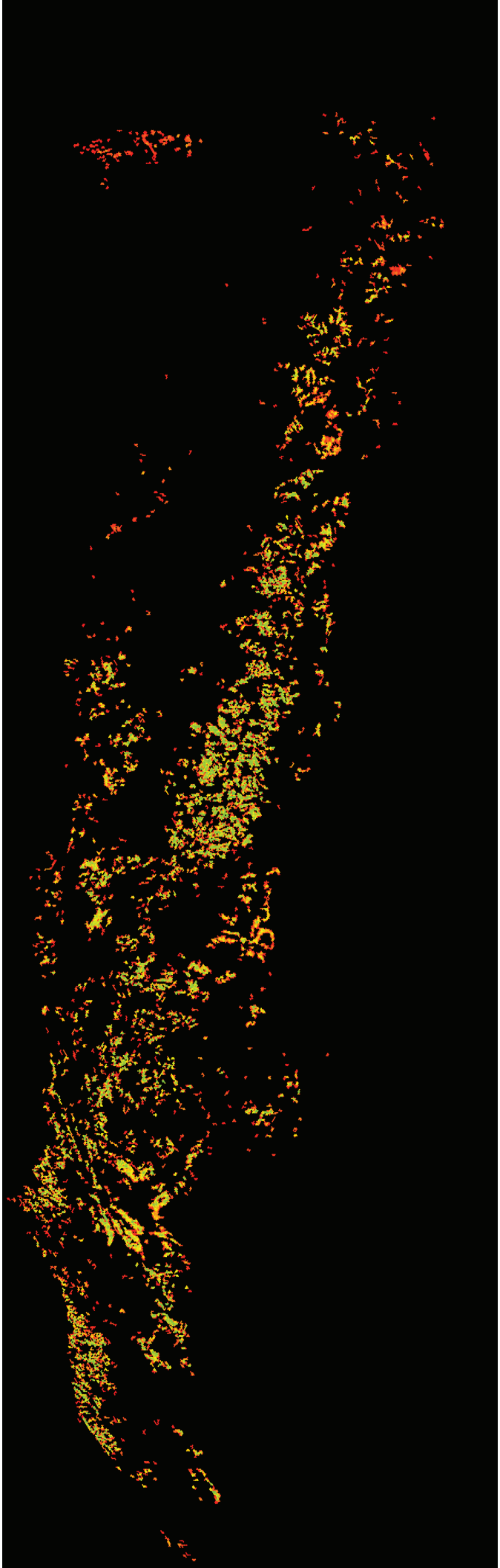
Notes on Movement

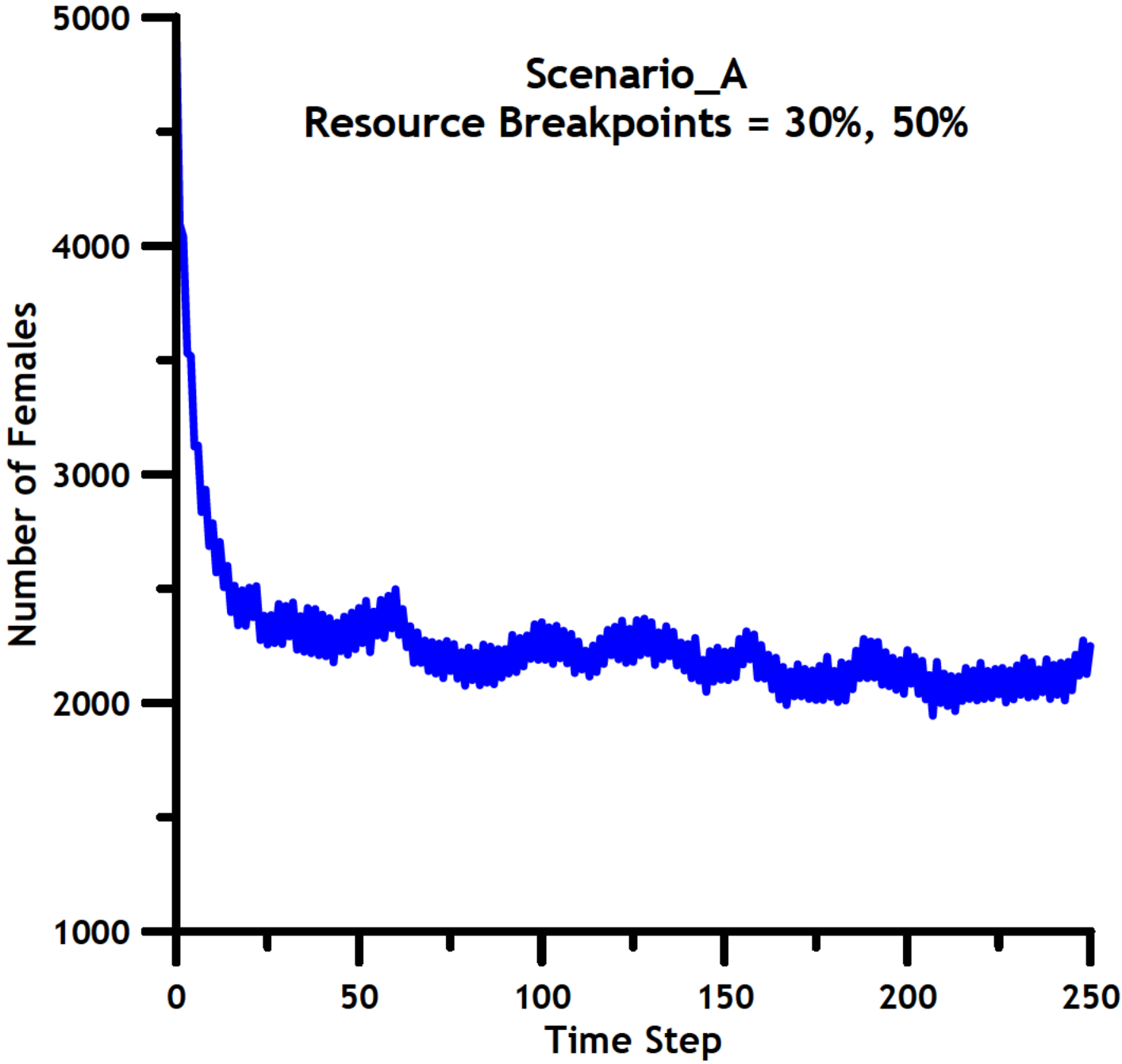
I have set up the scenario with 8 movement events. In order, these are (1) prospecting by all floater (non-territorial) owls, (2) dispersal and exploration of stage 0 owls, and (3-8) home range establishment, by province.

The first movement event proceeds the reproductive pulse. In it, all floaters are allowed to explore (prospect) for a vacant territory. The owls are allowed to search an area up to 500 hexagons (43,300 ha) in size. They do not disperse, and they terminate their search if they can identify a vacant territory with a cumulative score of at least 300. Individual hexagons range in score from 0 to 90, but some reserve strategies may include hexagons with scores up to 100. The territory size cannot be more than 5 hexagons (433 ha) in size. If a vacant territory with a cumulative score of at least 300 cannot be identified, then the exploration will continue for the full 500 hexagons. At that point, lower quality territories may be claimed. The minimum acceptable territory scores were set to 100 (cumulative) and 20 (individual hexagons).

Following the reproductive pulse, the recruits all disperse and then explore. According to Bob Anthony, stage 0 owls will not claim a territory. For this reason, the event that moves the stage 0 owls disperses them but allows no prospecting. These dispersers will move a distance determined by drawing a uniformly distributed random variate bounded by [0, 250] km. They will stop dispersing if they encounter a hexagon of score 60 or better. This reflects the assumption that hexagons with scores of 60 or more qualify as breeding habitat. The dispersing owls have no resource attraction, but they do have some repulsion. Repulsion increases from 0 in hexagons scored 10 to 90% in hexagons scored 0. The range of hexagon scores is 0-100.

Finally, six separate movement events are used to establish home ranges, one for each province. These events operate on both territorial owls and floaters, but they do not cause the loss or alteration of any territories. Letting floaters establish home ranges effectively just assigns these individuals a larger area from which they can draw resources. It does not assign them a territory or change their status as non-reproductive individuals.




Scenario_A
Resource Breakpoints = 30%, 50%
Number of Females
5000
4000
3000
2000
1000
0
50
100
150
200
250
Time Step

Scenario_A
Time Steps 50-150

Demographic Study Area	Mean Number of Female Owls
Not In A DSA	1798.90
Cle Elum	7.88
Coast Ranges	33.10
HJ Andrews	65.20
Klamath	31.50
Olympic	14.10
Rainier	13.70
South Cascades	88.68
Tyee	39.50
Warm Springs	15.50
Wenatchee	43.10
Hoopa	5.74
Marin	0.09
NW California	62.20
Simpson	17.10

Scenario_A
Time Steps 150-250

Demographic Study Area	Mean Number of Female Owls
Not In A DSA	1696.60
Cle Elum	12.60
Coast Ranges	38.80
HJ Andrews	74.60
Klamath	24.80
Olympic	10.10
Rainier	16.50
South Cascades	65.94
Tyee	36.20
Warm Springs	13.70
Wenatchee	33.30
Hoopa	6.67
Marin	1.60
NW California	64.20
Simpson	24.00

Scenario_A
Time Steps 150-250

Mean Score of Home Range Hexagons	Mean Number of Individuals with this Score
0 - 5	1.20
5 - 10	1.20
10 - 15	2.20
15 - 20	5.73
20 - 25	14.10
25 - 30	31.20
30 - 35	77.24
35 - 40	208.60
40 - 45	443.90
45 - 50	642.40
50 - 55	495.90
55 - 60	157.20
60 - 65	36.80
65 - 70	1.70
70 - 75	0.20
75 - 80	0.00
80 - 85	0.00
85 - 90	0.00
90 - 95	0.00
95 - 100	0.00

Scenario_A
Time Steps 150-250

Mean Score of Territory Hexagons	Mean Number of Individuals with this Score
0 - 5	1.30
5 - 10	1.20
10 - 15	2.60
15 - 20	4.50
20 - 25	9.11
25 - 30	16.20
30 - 35	33.70
35 - 40	58.83
40 - 45	86.72
45 - 50	118.60
50 - 55	417.40
55 - 60	627.80
60 - 65	664.30
65 - 70	60.70
70 - 75	9.06
75 - 80	5.80
80 - 85	1.10
85 - 90	0.51
90 - 95	0.00
95 - 100	0.00